Before the
Federal Communications Commission
Washington, D.C. 20554

2000 Biennial Regulatory Review --	)	
Streamlining and Other Revisions of	)	
Part 25 of the Commission's Rules	)	
Governing the Licensing of, and	)	IB Docket No. 00-248
Spectrum Usage by, Satellite Network	)	
Earth Stations and Space Stations	)	

SIXTH REPORT AND ORDER AND THIRD FURTHER NOTICE OF PROPOSED RULEMAKING

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By the Commission:

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I. INTRODUCTION

1. This *Sixth Report and Order and Third Further Notice of Proposed Rulemaking* represents the next step in our continuing examination of our rules governing satellite space station and earth station licensing. In the notice portion, we propose revisions to Part 25 of the Commission's rules[1] that should give earth station operators in the fixed-satellite service more flexibility in implementing state-of-the-art

[1] 47 C.F.R. Part 25.

earth stations. Specifically, we propose off-axis equivalent isotropically radiated power (EIRP)[2] envelopes for earth stations in the Fixed Satellite Service (FSS) in the conventional C-band and Ku-band.[3] Using these envelopes as criteria for licensing should allow us to license more earth station applications routinely, expediting the provision of satellite services to consumers and enhancing the types of services available, without increasing the likelihood of harmful interference to adjacent satellite operators or to terrestrial wireless operators. In the *Sixth Report and Order* portion of this document, we address two issues which are intertwined with the issues raised in this *Third Further Notice*, relating to earth station antenna gain pattern rules and VSAT networks. We stay the effectiveness of the antenna gain pattern rule changes pending our consideration of the off-axis EIRP envelope proposal in this *Third Further Notice*.

II. BACKGROUND

A. Two-Degree Spacing Framework

2. The Communications Act mandates that transmitting radiocommunication facilities must be licensed before they can operate.[4] The rules governing transmit-only and transmit/receive earth stations are contained in Part 25 of the Commission's rules.[5] The rules are intended primarily to ensure that satellite networks of space stations and earth stations can operate with a minimum of interference with respect to each other and with respect to other telecommunications services. Earth stations provide a critical link between satellites and terrestrial networks, and satellite networks depend on the Commission's earth station licensing rules to maintain an operating environment with a minimum of interference to other users operating in the band.[6]

3. As the satellite industry developed in the 1980s, the Commission instituted a 2° orbital spacing policy to maximize the number of in-orbit satellites operating in either the C-band or the Ku-band.[7] Previously, satellites had been operating 3° to 4° apart. Under the 2° orbital spacing framework, the Commission assigns adjacent in-orbit satellites to orbit locations 2° apart in longitude. This framework also established technical rules to govern earth stations communicating with these satellites, to ensure that

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[2] Equivalent Isotropically Radiated Power (EIRP) is the product of the gain of the antenna in a given direction relative to an isotropic antenna and the power supplied to that antenna. 47 C.F.R. § 2.1.

[3] For purposes of this Order, the conventional C-band is the 3700-4200 MHz and 5925-6425 MHz bands. The conventional Ku-band is the 11.7-12.2 GHz and 14.0-14.5 GHz bands.

[4] 47 U.S.C. § 301.

[5] 47 C.F.R. Part 25.

[6] 2000 Biennial Regulatory Review -- Streamlining and Other Revisions of Part 25 of the Commission's Rules Governing the Licensing of, and Spectrum Usage by, Satellite Network Earth Stations and Space Stations, *Notice of Proposed Rulemaking*, IB Docket No. 00-248, 15 FCC Rcd 25128, 25130 (para. 3) (2000) (*Notice*).

[7] *Notice*, 15 FCC Rcd at 25132 (para. 7), *citing* Licensing of Space Stations in the Domestic Fixed-Satellite Service and Related Revisions of Part 25 of the Rules and Regulations, *Report and Order*, CC Docket No. 81-704, FCC 83-184, 54 Rad. Reg. 2d 577 (released Aug. 16, 1983); *summary printed in* Licensing Space Stations in the Domestic Fixed-Satellite Service, 48 F.R. 40233 (Sept. 6, 1983) (*Two Degree Spacing Order*). *See also* Licensing of Space Stations in the Domestic Fixed-Satellite Service and Related Revisions of Part 25 of the Rules and Regulations, *Report and Order*, CC Docket No. 81-704, 99 FCC 2d 737 (1985) (*Two Degree Spacing Reconsideration Order*).

their operations do not cause unacceptable interference to adjacent satellite systems. Primarily, earth station technical requirements consist of minimum antenna diameter and maximum power level limits.

4. Antenna diameter is important because it affects the antenna gain. The antenna gain is the ratio of the power required at the input of a loss-free reference antenna to the power supplied to the input of a given antenna to produce, in a given direction, the same field strength or the same power flux-density at the same distance. When not specified otherwise, the gain refers to the direction of maximum radiation.[8] In other words, gain refers to an antenna's ability to collect, concentrate, and direct energy in a particular fashion, *i.e.*, a beam.[9] Many antennas are shaped like parabolas, or like large, curved bowls. The "axis," or boresight, is the line running through the center of the bowl and perpendicular to the plane of the edge of the bowl.[10] The boresight should extend directly into the antenna on the satellite with which the earth station is communicating. The majority of the energy is transmitted along the boresight in what is called the main beam of the antenna. The "off-axis" angle is the angle formed by the axis and any other line running through the center of the bowl.[11] The energy transmitted from an antenna forms "ripples," alternately increasing and decreasing in magnitude as the off-axis angle increases.[12] These ripples are called "side lobes."[13]

5. The antenna gain at various off-axis angles provides a measure of the interference potential of that earth station to other in-orbit satellites. For example, the antenna gain in the vicinity of 2° off-axis provides a measure of the potential of that earth station to cause interference to satellites located 2° away in orbit from the satellite with which the earth station is communicating. The gain of any earth station antenna must fall within the limits defined by equations in the Commission's rules. In other words, the main lobes and side lobes of an antenna must be less than the limits specified in those equations.[14] Because decreasing the antenna diameter produces wider main beams and larger side lobes, the antenna gain pattern envelope effectively creates a minimum earth station antenna diameter because at some point the main beam will become wide enough to cause unacceptable interference to adjacent satellites.[15]

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[8] *Notice*, 15 FCC Rcd at 25133 (para. 9), *citing* 47 C.F.R. § 2.1.

[9] *Notice*, 15 FCC Rcd at 25133 (para. 9).

[10] *Notice*, 15 FCC Rcd at 25133 (para. 9). This is true for center-fed antennas. However, since any portion of the bowl will effectively reflect the energy from the feed in the direction of the boresight, "offset fed antennas" can be constructed where the boresight is not necessarily perpendicular to the plane of the antenna's edge.

[11] *Notice*, 15 FCC Rcd at 25133 (para. 9).

[12] *Notice*, 15 FCC Rcd at 25133 (para. 9). Examples of these ripples can be seen in the antenna gain pattern diagrams in Appendix A of the *Notice*. *Notice*, 15 FCC Rcd at 25162-73 (App. A).

[13] *Notice*, 15 FCC Rcd at 25133 (para. 9).

[14] *Notice*, 15 FCC Rcd at 25133 (para. 10), *citing* 47 C.F.R. § 25.209.

[15] *Notice*, 15 FCC Rcd at 25133 (para. 11), *citing Two Degree Spacing Order*, 54 Rad. Reg. 2d at 605 (para. 93).

B. Current Earth Station Licensing Procedures

6. Currently, we "routinely" license C-band and Ku-band earth station facilities that meet the 2° orbital spacing technical requirements set forth in Part 25 of the Commission's rules.[16] In other words, if the earth station meets certain antenna diameter and power level restrictions,[17] we grant the earth station application without conducting a further technical review to verify that the earth station will not cause unacceptable interference into other satellite systems.[18]

7. The Commission began this proceeding in 2000 by inviting commenters to suggest revisions to the requirements for routine earth station processing, and by proposing a streamlined procedure for non-routine earth station applications.[19] In the *Fifth Report and Order* in this proceeding,[20] adopted concurrently with this *Sixth Report and Order and Third Further Notice*, the Commission establishes streamlined procedures for earth station applications that do not meet the revised routine processing standards. Those procedures are based on extensive comments filed in response to the *Notice* and a later 2002 *Further Notice* in this proceeding.[21] However, the *Fifth Report and Order* did not revise the basic framework of the Part 25 earth station licensing regime: Earth station applicants must meet *both* antenna diameter and power level requirements to be eligible for routine processing.

8. In this *Third Further Notice*, we invite comment on replacing the current Part 25 earth station licensing regime with an off-axis EIRP approach. Our goal is to give earth station operators flexibility to decrease their power levels to compensate for smaller earth station antennas, or to use larger earth station antennas to compensate for higher power levels. This increased flexibility should in turn enable the Commission to expedite its issuance of certain earth station applications considered non-routine under the rules adopted in the *Fifth Report and Order*. Moreover, adopting an off-axis EIRP envelope approach for

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16 *Notice*, 15 FCC Rcd at 25132 (para. 7), *citing* 47 C.F.R. Part 25.

17 47 C.F.R. §§ 25.134, 25.209, 25.211, 25.212. *See also* Routine Licensing of Earth Station in the 6 GHz and 14 GHz Bands Using Antennas Less than 9 Meters and 5 Meters in Diameter, respectively, for Both Full Transponder and Narrowband Transmissions, *Declaratory Order*, 2 FCC Rcd 2149 (Com. Car. Bur., 1987), *cited in* 47 C.F.R. § 25.134.

18 For purposes of this Order, we define "routine" earth stations as those that can be licensed without a case-by-case review. The Commission also grants "non-routine" earth station applications, but those applications require a case-by-case review to ensure that they will not cause harmful interference in a two-degree spacing environment. *Notice*, 15 FCC Rcd at 25132 (para. 7).

19 *See Notice*, 15 FCC Rcd 25128.

20 2000 Biennial Regulatory Review -- Streamlining and Other Revisions of Part 25 of the Commission's Rules Governing the Licensing of, and Spectrum Usage by, Satellite Network Earth Stations and Space Stations, *Fifth Report and Order*, IB Docket No. 00-248, FCC 05-63 (adopted Mar. 10, 2005) (*Fifth Report and Order*).

21 *Fifth Report and Order* at paras. 13-14; 2000 Biennial Regulatory Review -- Streamlining and Other Revisions of Part 25 of the Commission's Rules Governing the Licensing of, and Spectrum Usage by, Satellite Network Earth Stations and Space Stations, *Further Notice of Proposed Rulemaking*, IB Docket No. 00-248, 17 FCC Rcd 18585 (2002) (*Further Notice*). *See also Fifth Report and Order* at para. 13 (noting that interested parties were invited to submit additional comments in a status conference in February 2004). The *Notice* and *Further Notice* raised a number of issues in addition to routine earth station processing standards and non-routine earth station procedures. Many of those issues were resolved in earlier Orders in this proceeding. For a complete procedural history, see *Fifth Report and Order* at paras. 13-14.

FSS earth stations in the C-band and Ku-band would make those procedures consistent with the procedures for other earth stations.[22]

9. Before we invite comment on off-axis EIRP issues, we resolve issues deferred from the *Fifth Report and Order* that are interrelated with off-axis EIRP. In Section III.A., we adopt revisions to the earth station antenna gain pattern requirements. In Section III.B., we adopt the proposals from the *Notice* for very small aperture terminal (VSAT) networks using time division multiple access (TDMA), frequency division multiple access (FDMA) and code division multiple access (CDMA) transmission techniques. These two sections constitute the *Sixth Report and Order* in this proceeding.[23] We do not anticipate that these rule changes will increase the likelihood of harmful interference to adjacent satellite operators or to terrestrial wireless operators.

10. Section IV. is the *Third Further Notice* in this proceeding. In Section IV.A., we propose off-axis EIRP envelopes for FSS earth stations in the C-band and Ku-band. In Section IV.B., we invite comment on whether to adopt a procedure for applications for earth stations that exceed the applicable off-axis EIRP envelope. In Section IV.C., we propose new earth station application information requirements needed to implement off-axis EIRP envelopes. In Section IV.D., we seek further comment on issues raised by the use of contention protocols in VSAT networks. Finally, Section IV.E. invites comment on a proposal from the National Radio Astronomy Observatory (NRAO) to revise the rules governing the "Quiet Zone" for radio astronomy.[24]

III. SIXTH REPORT AND ORDER

A. Earth Station Antenna Gain Pattern Envelope

1. Background

11. As noted above, the Commission's current routine earth station standards include minimum antenna sizes. Those sizes are related to the Commission's antenna gain pattern requirements. Currently, the antenna gain pattern envelope begins at the same off-axis angle both within and outside the geostationary-satellite orbit (GSO) orbital plane, 1° off-axis for C-band earth stations and 1.25° off-axis

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[22] *See* 47 C.F.R. § 25.138 (Ka-band FSS earth stations); Procedures to Govern the Use of Satellite Earth Stations on Board Vessels in the 5925-6425 MHz/3700-4200 MHz Bands and 14.0-14.5 GHz/11.7-12.2 GHz Bands, *Report and Order*, IB Docket No. 02-10, FCC 04-286 (released Jan. 6, 2005) (*ESV Order*). In addition, the Boeing Company (Boeing) filed a petition for rulemaking on July 21, 2003, requesting, among other things, that the Commission adopt off-axis EIRP requirements for aeronautical earth stations. The Commission recently adopted a Notice of Proposed Rulemaking to invite comment on many of Boeing's proposals. Service Rules and Procedures to Govern the Use of Aeronautical Mobile Satellite Service Earth Stations in Frequency Bands Allocated to the Fixed Satellite Service, *Notice of Proposed Rulemaking*, IB Docket No. 05-20, FCC 05-14 (released Feb. 9, 2005) (*AMSS NPRM*).

[23] We base our conclusions in this *Sixth Report and Order* on the record developed in response to the *Notice* and *Further Notice*. A complete list of commenters is provided in Appendix A.

[24] *See* 47 C.F.R. § 25.203(f) (current Quiet Zone coordination requirements); *see also*, Amendment of Part 2 of the Commission's Rules and Regulations to Give Interference Protection to Frequencies Utilized for Radio Astronomy, Amendment of Part 3, 4, 5, 6, 7, 9, 10, 11, 16, 20, and 21 of the Commission's Rules and Regulations to Give Interference Protection to Frequencies Utilized for Radio Astronomy, *Report and Order*, Docket No. 11745, FCC 58-1111, 17 Rad. Reg. 1738 (1958) (*Quiet Zone Order*).

for Ku-band earth stations.[25] However, the antenna gain pattern equations allow side lobes outside that GSO orbital plane to be greater than allowed within the GSO orbital plane at off-axis angles less than 9.2°.[26] The smallest antenna we license routinely under our current rules at C-band is 4.5 meters in diameter, while at Ku-band the smallest antenna we routinely license is 1.2 meters in diameter.[27]

12. As the Commission noted in the *Notice* and the *Further Notice*, however, some earth stations with main beams that are too wide to comply with the Commission's rules may still be sufficiently narrow to avoid causing harmful interference to adjacent satellites.[28] In their initial comments, a number of parties proposed starting the antenna gain pattern envelope at a wider off-axis angle, to permit wider main lobes and therefore smaller earth station antennas, or, as an alternative, revising the antenna gain pattern envelope equations in the Commission's rules to allow larger side lobes.[29] In the *Further Notice*, the Commission invited comment on these antenna gain pattern proposals and certain related proposals.[30]

13. Based on the record in response to the *Further Notice*, we change the starting point for the earth station antenna gain pattern envelope within the GSO orbital plane to 1.5° off-axis. We also consider and reject a number of *Further Notice* proposals intended to minimize pointing error, and instead adopt a proposal from commenters to require VSAT remote terminals to cease transmissions if they lose synchronization, in light of the revised earth station antenna gain pattern envelope.[31] Further, we propose to revise the earth station antenna gain pattern envelope outside the GSO orbital plane. Finally, we address backlobe issues.

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[25] *See* 47 C.F.R. § 25.209(g). When viewed from any point on the earth's surface, satellites near each other in the geostationary satellite orbit (GSO) appear to lie approximately in one plane.

[26] *See* 47 C.F.R. §§ 25.209(a)(1), (2).

[27] *Notice*, 15 FCC Rcd at 25133 (para. 11). Although an antenna 1.2 meters in diameter does not fit within the envelope established in Section 25.209(a)(1) between 1° and 1.25° off-axis, the Commission found that this slight failure to meet the Commission's antenna gain requirements does not generally cause unacceptable interference to adjacent satellite operators, and therefore created an exception for 1.2-meter antennas operating in the Ku-band. Specifically, the side lobe envelope for a 1.2-meter antenna operating in the Ku-band was revised to begin at 1.25° off-axis. *See* 47 C.F.R. § 25.209(g); Amendment of Part 25 of the Commission's Rules and Regulations to Reduce Alien Carrier Interference Between Fixed-Satellites at Reduced Orbital Spacings and to Revise Application Processing Procedures for Satellite Communications Services, *Second Report and Order and Further Notice of Proposed Rulemaking*, CC Docket No. 86-496, 8 FCC Rcd 1316, 1322 (paras. 38-39) (1993) (*Ku-band Antenna Gain Pattern Revision Order*).

[28] *Notice*, 15 FCC Rcd at 25132 (para. 7); *Further Notice*, 17 FCC Rcd at 18594-95 (para. 20).

[29] *See, e.g.*, Spacenet Comments at 12-14; Hughes Comments at 5-6. *See also* SIA December 10, 2001 *Ex Parte* Statement at 15-21; PanAmSat October 22, 2001 *Ex Parte* Statement.

[30] *Further Notice*, 17 FCC Rcd at 18599-18613 (paras. 29-73). SIA states that its proposals in its 2001 *ex parte* statements regarding the starting point for the Ku-band antenna gain pattern envelope are superceded by its proposals in its Further Comments. SIA Further Reply at 1 n.2. SIA did not explain why it changed its proposal. For a summary of SIA's original antenna gain pattern proposals, we direct the reader to the *Further Notice*, 17 FCC Rcd at 18606-10 (paras. 53-62).

[31] *Further Notice*, 17 FCC Rcd at 18604 (para. 44).

2. Antenna Gain Pattern Within the GSO Orbital Plane

14. *Background.* To be eligible for routine processing, earth station licensees must meet the antenna gain pattern within the GSO orbital plane at every off-axis angle greater than 1° off-axis in the C-band, and 1.25° off-axis in the Ku-band.[32] In pleadings in response to the *Notice*, Hughes and other commenters proposed starting the Ku-band earth station antenna gain pattern envelope at 1.8° off-axis.[33] Hughes argued that, because the satellites serving the United States at that time were spaced at least 1.9 degrees apart, beginning the off-axis angle at 1.8° would not increase the potential for inter-satellite interference.[34]

15. After the comment period had closed on the *Notice*, PanAmSat filed an *ex parte* statement voicing concerns regarding earth station antenna pointing error and smaller-than-routine antennas. Pointing error occurs whenever the boresight of an earth station antenna is not aimed perfectly at the desired satellite.[35] The effect of pointing error on an antenna gain pattern is to shift the entire antenna pattern away from the desired direction, thus potentially increasing the antenna gain toward a neighboring satellite.[36] The impact of this pointing error is generally negligible when larger antennas are employed and the interference path falls into a valley between two sidelobes. However, as the earth station antenna diameter decreases, the width of the main lobe increases. As a result, a given amount of pointing error becomes more likely to cause harmful interference as the diameter of the earth station antenna decreases, because it becomes more likely that the adjacent satellite interference path will fall on the edge of the wider mainlobe.[37]

16. In the *Further Notice*, the Commission determined that Hughes's arguments in favor of increasing the starting point of the Ku-band antenna gain pattern envelope to 1.8° off-axis were persuasive.[38] The Commission also found, however, that PanAmSat's concerns regarding earth station antenna pointing error warrant consideration. Therefore, in the *Further Notice*, the Commission invited commenters to propose a specific off-axis angle at which to start the Ku-band antenna gain pattern envelope. This envelope starting point was to be less than 1.8° off-axis, and the difference between 1.8° and the starting point was to be sufficient to account for the potential for pointing error.[39] In other words, the Commission proposed starting the Ku-band antenna gain pattern envelope at 1.8° - x, where "x" is a constant representing the potential for pointing error, and asked commenters to recommend definitions for

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32 *Notice*, 15 FCC Rcd at 25133 (paras. 10-11); 47 C.F.R. §§ 25.209(a), (b), (g).

33 *Further Notice*, 17 FCC Rcd at 18599 (para. 32), *citing* Hughes Comments at 8-11. Spacenet argued that we should start the Ku-band antenna gain pattern envelope at 2.0° off-axis, because satellites spaced 2.0° apart in the GSO orbital plane appear to be 2.2° apart when viewed from the earth's surface. *See Further Notice*, 17 FCC Rcd at 18599-18600 (para. 32). The Commission found that Spacenet's assertion is incorrect for earth stations with angles of elevation less than 35°. *Further Notice*, 17 FCC Rcd at 18640-41 (App. B).

34 Hughes Comments at 8-11.

35 *See Further Notice*, 17 FCC Rcd at 18602 (para. 40).

36 *See Further Notice*, 17 FCC Rcd at 18602 (para. 40).

37 *Further Notice*, 17 FCC Rcd at 18602 n.92.

38 *Further Notice*, 17 FCC Rcd at 18602 (para. 39).

39 *Further Notice*, 17 FCC Rcd at 18602-03 (paras. 40-41).